A CORRECTION AND *PRIMA FACIE* TEST OF THE CANONICAL THEORY OF SHARE TENANCY

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Mark A. DeWeaver and James A. Roumasset

Working Paper No. 01-4
August 2001

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Mark A. DeWeaver[1] *and James A. Roumasset*[2]

presented to

The Society for the Advancement of Behavioral Economics Biennial Conference

Applied Behavioral Economics: Can It Improve Decisions and Policies? Is It Already Implicit in Successful Decision Making?

June 12, 2001

Washington, DC

[1] Managing Partner, Ithaca Advisors LLC. e-mail: madeweaver@yahoo.com
[2] Professor of Economics, University of Hawaii at Manoa. e-mail: jimr@hawaii.edu

Abstract

We show that Stiglitz's (1974) classic principal-agency theory of share tenancy does not imply, as commonly supposed, that the incidence of share tenancy increases with the tenant's degree of risk aversion nor that share contracts are superior to fixed-lease contracts for risk averse farmers. When the model is parameterized based on previous studies of Philippine agriculture, it predicts that fixed-lease contracts will be chosen when the farmers have slight or severe risk aversion and share contracts will be chosen for moderately risk averse farmers, albeit with tenant shares of 80% or higher. In contrast, the highest observed sharing rates in the study area were in the neighborhood of 2/3, with most farmers contracted on 50:50 sharing arrangements. We conclude that the risk-aversion vs. moral hazard theory is incomplete. Rent contracts must have additional disadvantages and/or share tenancy additional benefits that are not accounted for by static principal-agency theory.

1. Risk, Incentives and Tenure Choice

One of the earliest formulations of principal-agency theory can be found in the Stiglitz (1974) model of contract choice in agriculture. In this canonical account of the hidden action problem, the output of a landlord's farm depends on both the labor-effort of his risk averse tenant and a random state of nature. (It is convenient, though not necessary, to think of the landlord as being risk neutral.) Because the effort input is unverifiable, it cannot be directly specified in the contract--which sets only a tenant's share (α) and a fixed side payment (β)--but must be induced indirectly through the incentive properties of the contract terms. This leads to a trade-off between risk-bearing and effort-shirking costs: increasing the tenant's share improves incentives but also exposes him to more risk, making it more expensive for the landlord to satisfy the participation constraint.

This model is still regarded by many economists as the most plausible explanation available for the popularity of share tenancy. Indeed Sappington (1991) finds that "The classic example of the principal-agent relationship has a landlord overseeing the activities of a tenant farmer." For Hayami and Otsuka (1993), the Stiglitz setup "provides the most consistent explanation for the existence of the share contract" (p. 173), while Ray (1998) states that the "tension between the need to provide incentives to the tenant and the need to insure him…fundamentally motivates our view of contracting." (p. 435).[3]

[3] Stiglitz himself often cites his theory of share tenancy as an example of (socially) inefficient institutional choice induced by asset inequality (see e.g. The London Observer, April 29, 2001).

All of this is surprising given that (1) even when tenants are risk averse, Stiglitz (1974) does not imply that sharing is unambiguously preferred to rent (see Section 2) and (2) the theory has never been subjected to a test relating empirically observed tenant risk preferences to contract choice. This paper addresses these two points through a simulation methodology using real-world evidence on production and risk aversion to solve for the optimal contract. We find that the model fails to predict the popularity of 50:50 sharing (the most popular contract) and, surprisingly, that increasing the coefficient of partial risk aversion from moderate and intermediate levels to severe risk aversion causes the optimal contract to switch from share tenancy to rent.

As Allen and Lueck (1999) point out, the empirical evidence on the importance of risk is inconclusive. Cheung (1969), Higgs (1973) and Bardhan (1977), for example, find that share tenancy is more common when variance is high, while rent is more prevalent when variance is low, as the theory suggests. At the same time, however, Rao (1971), Reid (1973) and Allen and Lueck (1999) reach the opposite conclusion—that high-variance crops are more likely to be grown on rented land. (Allen and Lueck suggest that the relevant factor is not risk but rather the difficulty of measuring output, with wide output fluctuations making it easier for share tenants to underreport yields.)

Despite these problems, much of the literature seems to take Stiglitz (1974) as a starting point for thinking about agricultural contracts. Thus, Singh (1989) posits that "sufficient risk aversion on the part of the tenant will tilt the scales in favor of a share contract" (p. 44), while Hayami and Otsuka (1993) simply state that "the share contract is likely to be chosen in equilibrium" when the tenant is risk averse. (p. 173) More recently, Ghatak and Pandey (2000) assert that in Stiglitz (1974) "A sharecropping contract is shown to achieve the right balance between risk-sharing and incentive provision." (p. 304)

Such claims are premature. The distribution of tenancy contracts in the study area covered below and more generally in the Philippines is trimodal and 'U' shaped with 50:50 sharing being the most common contract, fixed-lease (rent) ranking second and 'lease-share' (tenant's share in the neighborhood of 2/3) third (Hayami and Otsuka, (1993)). At the same time, however, studies of the distribution of risk preferences among low income farmers (Binswanger (1980), Sillers (1980), Grisley (1980), Walker (1980), Binswanger and Sillers (1983)) show that this is unimodal and bell-shaped. If the Stiglitz theory is correct, this would imply that contracts would have a unimodal, bell-shaped distribution as well.

We show below that the theory neither rules out the possibility that α is increasing in tenant risk aversion nor that sharing will always be optimal for sufficiently risk averse tenants. Even with this correction, however, the question remains whether considerations of risk aversion and incentives are consistent with 50:50 sharing. The possibility remains that risk preferences and shirking propensities are such that the principal-agency theory can explain the popularity of share tenancy. To explore this question we compare actual tenure choice with that simulated from the theory and parameters based on previous studies of Philippine agriculture.

We begin with the results of Sillers' (1980) study of risk preferences among low-income farmers in Nueva Ecija, Philippines. (See also Binswanger and Sillers (1983).) Combining Sillers' findings with data on rice production and yield distributions (taken from Roumasset,1976 and Hayami and Kikuchi, 1982), makes it possible to determine, *via* simulation, what contract would be optimal for any given range of risk preferences, assuming ‘representative’ values for output variance and skewness. Sillers classifies his survey participants into seven classes corresponding to ranges of a constant partial risk aversion (CPRA) coefficient and gives the share of the participants in each class. Thus, we can find the approximate percentage of the people in the study who would sign a particular contract under the assumptions of the model. This information may then be compared with empirical evidence on the prevalence of different contract terms (*e.g.* 50% share *versus* rent) to determine whether or not the simulation results are consistent with what is observed.

The simulation results show that rent may in fact be optimal for risk averse tenants and that the optimal share is not necessarily decreasing in tenant risk aversion. The optimal share is 100% (*i.e.* rent) for risk neutral individuals, declines to 80% for the moderately risk averse and then rises to 100% for the highly risk averse. We also find that the model does a poor job of predicting the observed distribution of contracts. Based on Sillers' findings, we would expect to find that 58% of the tenants had shares of 80% or higher, 42% rented and none had shares of 1/2 or 2/3. In fact, empirical evidence from the study area shows that 50% shares were actually the most common, accounting for 58% of contracts, while rent accounted for 30% and shares around 2/3, the remaining 12% (Mangahas, Miralao and de los Reyes, 1976; Hayami and Kikuchi, 1982).

The remainder of the paper is organized as follows. We discuss the Stiglitz model in greater detail in Section 2 and present our parameterization of it in Section 3. Section

4 explains the simulation method. Section 5 contains our simulation results while Section 6 concludes with some remarks on the limitations of the principal-agency approach.

2. Risk Aversion and Shirking Incentives

Stiglitz' model of the insurance-incentives trade-off is introduced in Stiglitz (1974), Part II. Output in the absence of any crop damage is given by:

(1) $Q = T f(el)$

where T is the total acreage owned by the landlord, e is each tenant's (unobservable) effort level and l is the number of tenants per unit of land. Tenant income (Y) and utility (U) are then given by:

(2) $Y = \{ \alpha f(el) / l \} g + \beta$

(3) $U = E[U(Y)] + V(e)$

letting g denote the percentage of the harvest left undamaged (a stochastic variable), E the expectations operator and V the tenant's disutility of effort. Given α, β and l, the tenant chooses e by solving the incentive compatibility constraint:

(4) $E[U' \alpha f'(el) g] + V' = 0$ (incentive compatibility)

The landlord chooses the value of β required for the participation constraint to hold with equality. (This is a special case of Grossman and Hart's (1983) general result that the participation constraint must bind when the agent's utility function is additively separable in action and reward.) This is given as a function (h) of the tenant's reservation level of utility (W), α and l:

(5) $\beta = h(\alpha, l; W)$ (participation constraint)

Finally, the landlord chooses a contract that maximizes profit subject to the two constraints. That is, he chooses α and l to solve:

(6) $$\max_{\{\alpha,\, l\}} (1 - \alpha) f(el) - h\, l$$

The first order conditions for this problem are then shown to imply the following closed-form expression for the tenant's share:

(7) $$\alpha^* = \gamma\, (\delta \ln e / \delta \ln \alpha)_W / \{ c + (\delta \ln e / \delta \ln \alpha)_W \}$$

where γ is the share of labor in the absence of uncertainty, e is tenant effort and $c = 1 - E\,[U'\,g] / E\,[U']$. From this he concludes in Proposition 11 that: "If workers are risk averse, then $0 < \alpha < 1$" and "α is smaller the more risk averse the individual."

These conclusions overstate the implications of equation (7). First, Stiglitz overlooks the possibility that maximizing landlord profit over $\alpha \in [0,1]$ might lead to the corner solution $\alpha = 1$, as would be the case if the magnitude of the incentive effects were large relative to risk bearing costs. Since equation (7) is only an interior solution, it does not imply that the optimal share must be less than one.

A second problem is that the assertion that α is smaller the more risk averse the tenant assumes both that (1) c is increasing in tenant risk aversion and (2) $(\delta \ln e / \delta \ln \alpha)_W$ is independent of risk preferences. Neither of these is necessarily true, however. Since $E\,[U'\,g]/E\,[U']$ depends on the tenant's choice of e, it does not necessarily follow that this value is smaller for more risk averse tenants, as it would be if the marginal utilities (U') were exogenous. The effect of higher risk aversion on c is thus unclear.

There is also no reason to think that the value of $(\delta \ln e / \delta \ln \alpha)_{W}$ will be independent of the curvature of the tenant's utility function. Increasing the tenant's share has two effects on incentives. First (as has been recognized at least since Marshall's time), it raises the benefit to the tenant of an increase in effort at the margin because he receives more of the associated increase in output. Second (a point which the literature has not recognized), if the curvature of the tenant's utility curve is decreasing in income, receiving more of this output increase also lowers his risk premium. This creates an additional incentive for the tenant to increase his effort when his share is increased, and the magnitude of this effect will be increasing in risk aversion.

The trade-off between insurance and incentives is thus not as straightforward as is commonly believed. On the one hand, insurance considerations would suggest that a given high share would be suboptimal for highly risk averse tenants. At the same time, however, the more risk averse the tenant, the greater the incentive effect we might expect to be associated with that share. The net effect on the sum of risk-bearing and labor-shirking costs would appear to be ambiguous.

Indeed, we show in the subsequent sections that increasing risk aversion can lead first to a decline in alpha as expected but then to an increase. That is, the parametarized model predicts that rent is the optimal contract for both risk neutral and substantially risk averse tenants. It is only for moderately risk averse tenants that share tenancy is optimal, and, even then, the tenant's optimal share is so high that the contract closely resembles a fixed lease.

3. Parametarizing the Principal-Agency Model

A direct test of the effort-shirking versus risk-bearing hypothesis is not feasible because effort is unobservable. Moreover, Stiglitz assumes that labor is observable but effort is not. In fact, landlords do not observe labor directly either. Therefor, we follow the labor-shirking version of the model described by Ray (1998).

We abstract from the problem of the landlord's choice of l and assume Cobb-Douglas production with constant returns to scale and labor and land as the only inputs:

(8) $$Q = g\, C\, L^{a} H^{(1-a)}$$

where C is a constant, L is labor, H is land and a is the output elasticity of labor. Output per hectare (q) is then given by:

(9) $$q = g\, C\, \lambda^{a}$$

where λ (= $1/l$) is labor per hectare.

A tenant’s total income, net of the opportunity cost of his labor input (w), is given by:

(10) $$\pi = D\,(\alpha\, q + \beta - w\lambda)$$

where D is the total number of hectares he farms. We follow the empirical literature on farmer risk preferences and assume that the tenant has a constant partial risk aversion utility function (CPRA) described in Binswanger (1980) and Sillers (1980):

(11) $$U(\pi) = (1-s)\,\pi^{(1-s)}$$

The concept of partial risk aversion was introduced by Menzes and Hanson (1970) and Zeckhauser and Keeler (1970). (See Binswanger (1981) for a summary of this literature.) It is measured by:

(12) $$s = -M\,(U_{\omega\omega} / U_{\omega})$$

where ω is initial wealth and M is the certainty equivalent of a new prospect. (Note that this is equivalent to relative risk aversion when initial wealth is zero.) In our CPRA function (11), s is a constant. This implies that an individual's preferences over a given set of lotteries will be unchanged if the payoffs are all increased (decreased) by the same factor. For example, a farmer who was indifferent between a lottery paying ₱ 50 with certainty and one paying ₱ 45 with a 50% chance and ₱ 95 with a 50% chance would also be indifferent between receiving ₱ 500 with certainty and a lottery paying ₱ 450 and ₱ 950 with equal odds. (₱ denotes Philippine pesos, the currency used in Sillers' experiment.)

Following Antle and Goodger (1984), we may express expected utility as a function of the first three moments of the probability distribution for the random variable (g) by expanding the utility function about the expected value of the tenant's income ($\bar{p}$), taking expectations and ignoring higher order terms:

$$(13)\qquad E\,[U(\pi, \lambda)] \cong (1\text{-}s)\,\bar{p}^{\,(1\text{-}s)} - s\,(1\text{-}s)^2\,\bar{p}^{\,-(s+1)}\,\mu_2/2 + s\,(s+1)(1\text{-}s)^2\,\bar{p}^{\,-(s+2)}\,\mu_3/6$$

where μ_i denotes the $i^{\underline{th}}$ moment of the probability distribution for the tenant's income. (See Note 2 for a brief review of the evidence from experimental economics on preference for positive skewness.)

The tenant's incentive compatibility constraint is given by:

$$(14)\qquad [\bar{p}^{\,-s} + s(s+1)\,\bar{p}^{\,-(s+2)}\,\mu_2/2 - s(s+1)(s+2)\,\bar{p}^{\,-(s+3)}\,\mu_3/6]\,\delta\bar{p}/\delta \boldsymbol{l} =$$
$$(s/2)\,\bar{p}^{\,-(s+1)}\,\delta\mu_2/\delta \boldsymbol{l} - (s/6)(s+1)\,\bar{p}^{\,-(s+2)}\,\delta\mu_3/\delta \boldsymbol{l}$$

The left hand side of equation (14) is simply the increase in expected utility that could be achieved through a unit increase in expected income ($\bar{p}$) multiplied by the increase in $\bar{p}$

that would result from a unit increase in labor. The right hand side, on the other hand, is the sum of two sources of marginal disutility. The first term gives the loss in utility resulting from the increase in the variance of tenant income that an additional unit of labor would bring about. The second term is the corresponding loss (gain) in utility from the increased left (right) skewness of tenant income that would result from an extra unit of labor. Thus, equation (14) is simply equates the benefits and costs of labor at the margin.

4. The Simulation Method

The simulation is designed to identify the conditions under which different types of contracts would be preferred, with the goal of establishing whether or not the most commonly chosen contracts would be observed under circumstances consistent with the empirical evidence. Specifically, we want to establish how often 1/2 and 2/3 shares and rent contracts would be chosen by landlords facing realistic levels of output variance and skewness, assuming that their tenants were drawn from a pool of farmers identical (in terms of risk preferences) to the participants in the Sillers (1980) study.

The first step is to solve for the opportunity cost (w) of tenant labor. Then, assuming that the share has already been chosen, we may solve the participation and incentive compatibility constraints simultaneously for l^* and β. As this cannot be done analytically, the software package *Mathematica* (Version 3.0) is used to find solutions numerically for given values of risk aversion (s), variance(σ^2), skewness (K), tenant's share (α) and elasticity of effective labor (a). (See Note 1 for the commands used.) Having determined l^* and β, it is straightforward to find the corresponding landlord profit. Finally, this procedure is repeated for other share values, the resulting profits are compared and the landlord's profit- maximizing share is chosen.

Before presenting the results, it is necessary to describe the sources for the parameter values used. Values for the coefficients of partial risk aversion came from Sillers (1980). Participants in this survey were asked to choose among seven lotteries (H, L) each paying either a high amount (H) or low amount (L) with a fifty-fifty chance. The largest payoffs were those offered in the following set of lotteries: O - (500, 500); A - (450, 950); B - (400,1,200); C - (300, 1,500); D - (100, 1,900); E - (0, 2,000); F - (-150, 2,100). (All values are in Philippine pesos.) In choosing a particular alternative, an individual revealed to which of seven risk aversion 'classes' he or she belonged. These were: 'extreme' (choice O) - CPRA coefficients (s) between 7.506 and ∞; 'severe' (choice A) - s between 1.743 and 7.506; 'intermediate' (choice 'B') - s between .812 and 1.743; 'moderate' (choice 'C') - s between .316 and .812; 'slight-to-neutral' (choice 'E') - s between 0 and .316; 'neutral-to-preferring' - s between -.214 and 0; and 'preferring - s between -.214 and -∞. (Note that (11) is only a valid utility function for $\pi \geq 0$. Assuming asset integration, however, subtracting a constant from all the lottery payoffs would have no effect on preferences, even if this resulted in negative values. Thus, these cutoff values of s characterize individuals' attitudes towards both gains and losses.)

Sillers' survey also included sets of lotteries with the same structure as these seven choices but with all payoffs reduced by a common factor—for example, all the payoffs might be reduced to one tenth of the values given above. Constant partial risk averse (CPRA) preferences would imply that the percentage of survey participants making a particular choice would not vary with such changes. In fact, the shares were not constant as the amounts involved for choice ‘O’ rose from ₱ 1 to ₱ 500, and mean risk aversion was found to increase gradually over this range. However, the increase was small enough in comparison to the increases in the scale of the game for Binswanger and Sillers (1983) to conclude that CPRA utility functions provide acceptable approximations to the true structure of farmers’ preferences. For purposes of the simulation, the percentages for the ₱ 500 level (see Figure 1) seem likely to be the most appropriate to decisions affecting contract choice—₱ 500 was about 1.4 month’s wages for the average survey participant. In effect, the assumption is that partial risk aversion is approximately constant at these levels when large-scale prospects are involved.

Siller's results on risk aversion are quite similar to the findings of three other studies—Binswanger (1980), Grisley (1980) and Walker (1980)—which used the same methodology to evaluate the risk preferences of low income farmers in India, Thailand and El Salvador, respectively. (See Figure 2 for a comparison of the four studies based on data given in Binswanger and Sillers (1983).) All found that partial risk aversion increased quite slowly with the magnitude of the payoff scale and all reported unimodal distributions with peaks in the intermediate/moderate range of partial risk aversion coefficients.

In addition to the data from the Sillers' (1980) study, we also used statistics on rice production from Laguna Province, Philippines. In that area, prior to the land reforms of the mid-70's, share tenancy was one of the most common agricultural contracts --about 70% of the farms in the two villages studied by Hayami and Kikuchi (1982) were under share tenancy contracts prior to 1976. Hayami and Kikuchi (1982, Chapter 6) found an output elasticity of labor of .27 for small farms under rental contracts. If we imagine all other factors being held constant at their average values, this would imply the Cobb-Douglas production function:

(15) $\ln q = 0.27 \ln \boldsymbol{l} + \ln C$

Output per hectare for these farms was about four tons per season, while the labor input was 105 man-days per hectare. Using this data, we find that C= 1.14, implying:

(16) $q = 1.14 \; \boldsymbol{l}^{0.27}$

If 36% of the crop was lost to pests, typhoons and other natural causes, as was typical for the Laguna farms surveyed in Roumasset (1976, Chapter 5), in the absence of such crop damage (*i.e.*, g =1), output would have been 6.3 tons (assuming other inputs such as fertilizer were held constant at their mean levels). Assuming the same factor shares under these ideal conditions, we would have found C = 1.78 implying:

(17) $y = 1.78 \, g \; \boldsymbol{l}^{0.27}$.

Next, we need to solve for w. Since (17) was derived from data on farms under rent contracts, it seems reasonable to use a value for which the model's prediction is consistent with Hayami and Kikuchi's observations. We should find both that rent would be optimal and that the tenant chooses $\boldsymbol{l}^* = 105$. To do this calculation, we need two additional pieces of information not given by Hayami and Kikuchi--the first three moments of the g distribution and a risk aversion level for the typical renter. We derive the moments of the g distribution from data on crop damage for the municipality of Binan (Laguna, Philippines) presented in Roumasset (1976, Table 5.5). This was obtained from interviews with a group of thirty-three farmers on crop damage for the years 1969, 1970 and 1971. Their reports on percentage losses relative to the undamaged maximum have a sample mean of 0.64, variance of .08 and skewness of -.014. (Roumasset (1976) also reports that farm sizes (D) of 2 hectares are typical for this area. This is used in equation (10) to calculate tenant income.)

We used a trial and effort method to find a value of w consistent with the following three points: (1) the tenant optimally chooses $\lambda = 105$, (2) the landlord optimally chooses a rent contract and (3) the moments of the g distribution are those given above. (See Note 3 for details.) The result was $w = .011$.

5. Tenant Risk Aversion and the Optimal Contract

We generated results for values of s from 0 to 7.5 in increments of .05 (with the exception of $s = 1$, at which point the tenant's optimization problem is not well defined). For each value of s, we computed l^* and landlord profit for eleven contracts: $\alpha = 50\%$, 55%, 60%, …, 100%. We then compared landlord profits for these eleven values of the tenant's share to find the profit-maximizing share (α^*)

Figure 3 shows values of l^* for two contracts-- $\alpha = 100\%$ (*i.e.* rent) and $\alpha = 50\%$. Evidently, changing the value of s has implications for incentives--otherwise, l^* would be constant for any given contract. From Equation 13, we can see that such incentive effects result from the impact of changes in s on the benefit and cost of labor at the margin (on the left hand and right hand sides of Equation 14, respectively). An incremental increase in the labor input has two effects: (1) it unambiguously increases all three moments of the distribution ($\bar{p}, \mu_2, \mu_3$) and (2) by increasing $\bar{p}$, it decreases the disutility associated with the second and third moments, since this is proportional to $\bar{p}^{-(s+1)}$ and $\bar{p}^{-(s+2)}$, respectively.

The relative magnitudes of these effects depend on the value of s. For values of s from zero to approximately 0.65, the first effect dominates. Increasing s within this range leads to lower values of $\boldsymbol{l}^*$ because the benefit of increasing $\bar{\boldsymbol{p}}$ is outweighed by the costs associated with higher values for μ_2 and μ_3. When s is greater than 0.65, on the other hand, the second effect becomes important. In this range, increasing the mean significantly lowers the weightings associated with the second and third moments in the expected utility function (Equation 13). As a result, the value of $\boldsymbol{l}^*$ under a given contract is increasing in s.

Figure 4 plots the landlord's profit-maximizing share (α^*) as a function of s. We find that the optimal share is only decreasing in s for values from $s = 0$ to approximately 0.65. For higher levels of risk aversion, α is increasing in s and rent is optimal for all $s > 1$.

This result is closely related to our findings on the effects of changes in s on incentives. When s is high, incentivizing the tenant to raise the value of $\bar{\boldsymbol{p}}$ through increasing his labor input also results in a relatively large reduction in the disutility associated with the second and third moments. Higher tenant's shares under these circumstances increase the landlord's profit in two ways: first, by raising total output and second, by making the participation constraint easier to satisfy. When s is low, on the other hand, an increase in $\bar{\boldsymbol{p}}$ does not lead to as large a reduction in the weightings of the variance and skewness in the utility function. In this case, raising the mean through improving incentives has less impact on the participation constraint and decreasing the tenant's exposure to risk through lowering his share becomes optimal.

Sillers found that 43% of his survey participants fell in the 'intermediate' risk aversion category, with $0.812 < s < 1.74$. Assuming that individuals were distributed uniformly throughout this range, we would have $1 < s < 1.74$ for about 80% of this group--*i.e.* for about 34% of all participants; $0.812 < s < 1$ for about 20% of this group, or 9% of participants. For 49% of participants, $0 < s < 0.812$, while for 8%, $s > 1.74$. Thus, Figure 4 suggests that shares between 80% and 100% should be the most commonly observed contracts, as we have $0 < s < 1$ for about 58% of participants. Similarly, we should find that rent contracts account for the remaining 42%.

Figure 5 compares these results with the findings of two empirical studies of tenure arrangements in southeast Luzon. Previous studies have found that the distribution of tenure choice in the study are is 58%, 1/2 shares, 30%, fixed lease (rent) and 12%, shares in the neighborhood of 2/3. (Mangahas *et al* (1976), Hayami and Kikuchi (1982)) Evidently the model does a poor job of replicating the observed contract distribution. It fails to predict that the most popular contracts ($\alpha = 1/2, 2/3$) would be observed at all and predicts instead that shares between 80% and 100% would be the most common, although these are seldom, if ever, observed. The model's prediction that 42% of tenants would rent is also considerably higher than the 30% reported by Hayami and Kikuchi.

Note that these differences between predicted and observed contract distributions cannot be attributed to sampling error. No matter how risk preferences are distributed among low-income farmers, we would always find that zero percent of the contracts would be predicted to specify 1/2 and 2/3 shares because these are not found to be optimal for *any* value of *s*. We can thus categorically rule out the possibility that the observed distribution was generated by the process described by the model. In short, the canonical theory is rejected at the 0% significance level.

6. Conclusion

Stiglitz's theory of share tenancy serves as an important prototype for principal-agency theory and demonstrates the possibility that share contracts can emerge as the pairwise-efficient result of rational choice. But a theory of share tenancy must do more than demonstrate the possibility of existence. It should be capable of explaining the pervasive stylized facts of tenure choice. Stiglitz's proposition 11, combined with the frequently-observed unimodal distribution of farmer risk preferences, implies a unimodal distribution of tenancy shares. But the actual distribution of shares is U-shaped and trimodal, with 50% being both the most frequent and lowest share reported.

This consideration suggests a reexamination of the theory. We find , contrary to what has allegedly been demonstrated in the literature, that there are no theoretical grounds for ruling out the possibility that high tenant shares, including 100%, are optimal for more risk averse farmers. It is only for moderately risk averse tenants that share tenancy is optimal, and, even then, the tenant's optimal share is so high that the contract closely resembles a fixed lease.

The predicted contract distribution has three characteristics which sharply differentiate it from what is observed empirically: (1) The mean share is above 90%--considerably to the right of the observed mean, 67%. (2) Optimal shares are found only in the range of 80% - 100%, while the actual range is 50% - 100%. (3) The distribution is unimodal and bell shaped, rather than trimodal and 'U' shaped. Thus, the model underpredicts the diversity of real-world contracts and cannot explain why shares much lower than one would ever be chosen. Ironically, therefore, the received theory of share tenancy can be better described as a theory of fixed lease contracts.

Despite inevitable simplifications in the parametarization of the model, our analysis demonstrates that the insurance-incentives trade-off story is less intuitively plausible than many authors have claimed. While we cannot rule out with absolute certainty, that there is no possible utility function, distribution of risk preferences, and attitudes towards effort shirking that would reconcile observed frequencies of tenure choice with static principal-agency theory, that case has not been made. A more promising strategy for restoring the applicability of principal-agency theory for the problem of tenure choice would be to incorporate some dynamic advantages of share tenancy and dynamic disadvantages of fixed-lease.

A more fundamental problem with the theory is that it assumes what may be an excessively simplistic account of decision making under uncertainty: each tenant has a built-in risk-aversion parameter and maximizes expected utility. In fact, evidence from experimental economics (such as that cited in Note 4) suggests that things are not so straightforward. Probability weighting, for example, could have important consequences and empirical testing will be further complicated if the weights differ from individual to individual. Similarly, the decision-making process may depend on the way the tenant perceives his situation (as is the case where preference reversal is observed). In that case, farmers may be making decisions related to agricultural production in an entirely different manner to choices made in Binswanger/Sillers-style experimental gambling games.

There would, in any case, also appear to be some important dynamic features of the landlord-tenant relationship that are missing from the static incentives vs. risk bearing theory. As landlord-tenant relationships are almost always long-term, it seems inappropriate to treat the tenant's effort as unobservable. Even where monitoring is prohibitively costly, a landlord who can accumulate data on yields over a number of periods would be able to estimate the tenant's effort level statistically if he knew the distribution of the random disturbance (*g*). This would make it possible for effort to be specified in a contract similar to that in Rubinstein and Yaari (1983), where first-best outcomes are achieved through specifying a penalty that will apply in the event that a prespecified statistic falls below a certain value.

In addition, if there are transaction costs associated with finding new tenants, we might expect the landlord to offer the tenant more than his reservation utility in order to keep him in the relationship (DeWeaver, 1998, Chapter 4). This conjecture would be consistent with the observation that share tenants tend to enjoy relatively high incomes for their communities, as well as with the fact that in some places (*e.g.* the Philippines) tenancy titles may be bought and sold. Were the participation constraint always binding, the discounted present value of tenant income net of opportunity costs would be zero and such a market could not have developed.

A final difficulty with the principal-agency approach is that it does not include any role for transaction costs associated with "land mining." In practice, tenants may cause serious deterioration of soil quality through overuse of fertilizer, improper tilling practices and other abuses which make possible bigger harvests in the short term while lowering long-term yields (Allen and Lueck, 1992). It seems unlikely that providing incentives for proper land use would not be one of the landlord’s objectives in contract selection (see e.g., Alston, Datta and Nugent; 1984; Roumasset and Uy, 1987).

Thus, the Stiglitz (1974) model may be of questionable usefulness as an explanation for agrarian institutions. First, our simulation results show that the theory (1) does not necessarily imply that share tenancy is optimal even when tenants are risk averse and (2) fails to predict the empirically observed distribution of contracts. Naturally, there may be special assumptions about the form of the utility function and the distribution of tenant attitudes towards effort and risk under which successful predictions might be obtained. But prior to showing what these assumptions are, and in the absence of supporting empirical evidence, there is no reason to suppose that they are intuitively plausible. Second, dynamic considerations and transaction costs related to asset abuse suggest that real-word landlord-tenant relationships are more complex than those between the model’s principals and agents. It thus seems likely that we must look beyond the trade-off between risk bearing and labor shirking costs for a satisfactory explanation of tenure choice.

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Notes

1. *Mathematica commands*. The 'Profit' module shown below finds landlord profit for given values of the risk aversion coefficient (risk), variance (var), skewness (skew), tenant's share (alp) and opportunity wage (wag). First, the FindRoot command finds values for the labor input (L) and side payment (b) that solve the participation and incentive compatibility constraints. (The numerical solution method uses 'c' and 'd' as starting values for L and b, respectively.) These values are then used to calculate landlord profit. The final Print command produces output in the form: 'risk', landlord profit, L, b.

```
Profit[risk_,var_, skew_, alp_,wag_,c_,d_]:=Module[{r,s, K, a, x, v,W,C,D},
r=risk; s=var; K=skew; a=alp;W = wag;C=c;D=d;
L=x/.FindRoot[
(* incentive compatibility constraint *)
{         ( 1 + (.5r(1+r)(2(1.1392a(x^.27)-v-W*x))^(-2))12.6736(a^2)s(x^.54)
                - .1667r(1+r)(2+r)(2(1.1392a(x^.27)-v-W*x)^(-3))45.1180(a^3)(x^.81)K
                              )2(.3076a(x^-.73)-W)
          ==.5r(2(1.1392a(x^.27)-v-W*x)^(-1))6.8437s(a^2)(x^-.46)
          -.1667r(1+r)(2(1.1392a(x^.27)-v-W*x)^(-2)) 36.5456K(a^3)(x^-.19),
```

```
(* participation constraint *)

        2(1.1392a(x^.27)-v-W*x)- .5r(1-r)(2(1.1392a(x^.27)-v-W*x)^
        (-1))12.6736(a^2)s(x^.54)
        + .1667r(1-r)(1+r)(2(1.1392a(x^.27)-v-W*x)^(-2))45.1180(a^3)(x^.81)K
        == 0},{x,C},{v,D}][[1]]   ;


(* To find b we solve the same two equations but this time take the second element of the
solution vector ([[2]]) *)
b=v/.FindRoot[
{  (  1 +(.5r(1+r)(2(1.1392a(x^.27)-v-W*x))^(-2))12.6736(a^2)s(x^.54)
-.1667r(1+r)(2+r)(2(1.1392a(x^.27)-v-W*x)^(-3))45.1180(a^3)(x^.81)K
                                                  )2(.3076a(x^-.73)-W)
==.5r(2(1.1392a(x^.27)-v-W*x)^(-1))6.8437s(a^2)(x^-.46)
     -.1667r(1+r)(2(1.1392a(x^.27)-v-W*x)^(-2)) 36.5456K(a^3)(x^-.19),
2(1.1392a(x^.27)-v-W*x)- .5r(1-r)(2(1.1392a(x^.27)-v-W*x)^(-1))12.6736(a^2)s(x^.54)
+ .1667r(1-r)(1+r)(2(1.1392a(x^.27)-v-W*x)^(-2))45.1180(a^3)(x^.81)K
== 0},{x,C},{v,D}][[2]]   ;


Print[   r," ",(1-a)2(1.1392a(L^.27) )+ 2b," ",L,"   ",b, "   "];
            ]
```

2.) *Preference for positive skewness*. While many authors consider only the effects of the mean and variance on expected utility, several studies have concluded that there are good reasons for including skewness as well. Experimental findings such as those of Coombs and Pruitt (1960), Mao (1970) and Alderfer and Bierman (1970), for example, have made a convincing case that many people prefer right-skewed distributions, even to the point of being willing to accept a lower mean in exchange for more positive skewness. Presumably this results from a disaster avoidance motive—it seems intuitively plausible that of two lotteries with the same mean and variance, the one with smaller probabilities of very bad outcomes would be chosen. Menezes, Geiss and Tressler (1980) provide a choice theoretic motivation for this idea, showing that individuals will exhibit 'downside risk aversion' if their utility functions have a positive third derivative—as is the case, for example, with our CPRA specification.

3.) *Probability weighting and preference reversal*. Kachelmeier and Shehata (1992) carried out a study similar to Sillers', using lotteries with real money payouts to measure attitudes toward risk among a group of Chinese college students. In this study, risk preferences were derived from the prices at which participants were willing to sell lotteries rather than from the Binswanger/Sillers lottery choice method. For the lotteries most comparable with those in Sillers' experiments (those with a 50% chance of winning), Kachelmeier and Shehata also found that the degree of risk aversion varied only slightly with a ten-fold increase in the magnitude of the prize. Interestingly, risk aversion levels for these 50% lotteries were found to be quite low, with the ratio of certainty equivalent to expected value at the highest payoff level being very close to one (implying risk neutrality). The studies on low-income farmers, by comparison, did not find ratios above 0.8 at any payoff level.

Varying the odds of winning also made it possible to capture an effect which could not be measured in experiments involving only 50:50 gambles. Participants were found to become less risk averse as the odds of winning decreased. The average certainty equivalent/expected value ratio was found to be as high as four for chances below 5%, but fell steeply over the 5% to 30% range and remained close to one for the 30% to 100% range. This trend is consistent with the results of many other studies on 'probability weighting'—evidence cited in Camerer (1995) includes Preston and Baratta (1948), Mosteller and Nogee (1951), Edwards (1953) and Kahneman and Tversky (1979).

One possible explanation for the low levels of risk aversion found by Kachelmeier and Shehata (1992) is the fact that their study was based on lottery pricing rather than on choices among lotteries. While the two approaches are equivalent under the usual axioms of utility theory, many studies have noted that preferences elicited under one method may be inconsistent with those revealed under the other. Evidence on this phenomenon, known as preference reversal, includes Lichtenstein and Slovic (1971, 1973), Kahneman and Tversky (1979) and Tversky, Slovic and Kahneman (1990). A typical scenario involves a choice between two gambles, one offering a low probability of winning a large sum of money, the other a high probability of winning a small sum. If asked to choose between the two, many people pick the latter, but simultaneously report a higher selling price for the former. Thus, it appears that the lottery choice method may lead subjects to exhibit risk averse behavior, while the lottery pricing method may result in risk preferring behavior.

The evidence on preference reversal and probability weighting suggests that, had the studies on low-income farmers used a lottery pricing method or lotteries with smaller chances of winning, they might have found much lower risk aversion levels. Thus, it may be safer to view their results as providing only an upper bound on risk aversion. Preference reversal and probability weighting also present some obvious challenges to utility theory in general and to this model's assumption that tenants maximize expected utility in particular. As Roth (1995) points out, however, the utility maximization paradigm may still be useful as an approximation. Even if it actual tenants do not literally maximize utility, it is not clear that discarding this assumption would allow us to capture any additional economicly relevant effects.

4. *Calculating w*. Since we don't know to which of Sillers' risk aversion categories the farmers in Hayami and Kikuchi's survey belonged, we search for suitable values of w for each of them. Replacing each range of values for s with its midpoint, we have $s = 4.625$ for 'severe' risk aversion, $s = 1.278$ for 'intermediate', $s = 0.564$ for 'moderate' and $s = 0.158$ for 'slight-to-neutral'. (None of Siller's survey participants fell in the risk loving category at the ₽500 payoff level and it also seems reasonable to rule out the 'extreme' category as this included only 2% of participants.)

Using a *Mathematica*'s 'FindRoot' command, which uses a numerical algorithm based on Newton's method, we found (through trial and error) that $\boldsymbol{l}^* = 105$ solved the participation and incentive compatibility constraints, for the following values of w, with $\alpha = 1$ (a rent contract) and the moments of the g distribution derived from Roumasset (1976):

s	*w*
4.625	0.0113
1.278	0.0110
0.564	0.0067
0.158	0.0076

We then repeated this procedure for lower values of α. This revealed that only in the first two cases would a rent contract be optimal for the landlord. As both 0.0113 and 0.0110 are approximately equal to 0.011, we used this value for *w*.

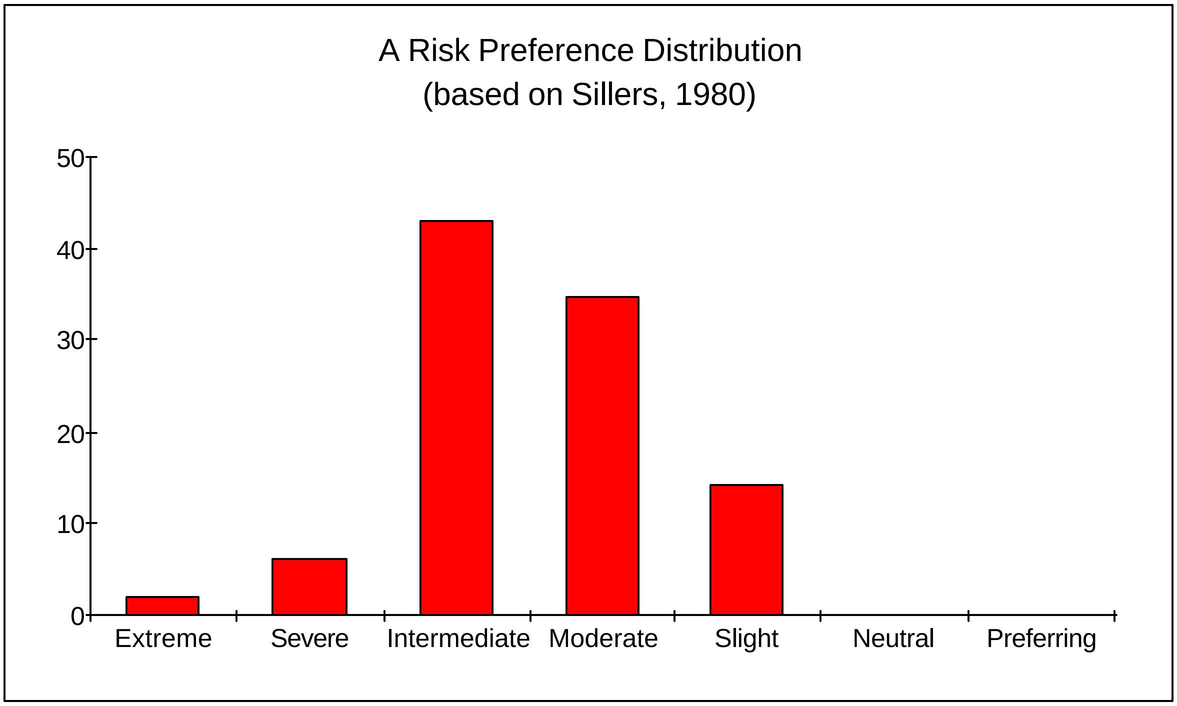

Figure 1. Risk preferences for low-income farmers in Neuva Ecija, Philippines (₱500 payoff scale). The vertical axis gives the percentage of survey participants in each class.

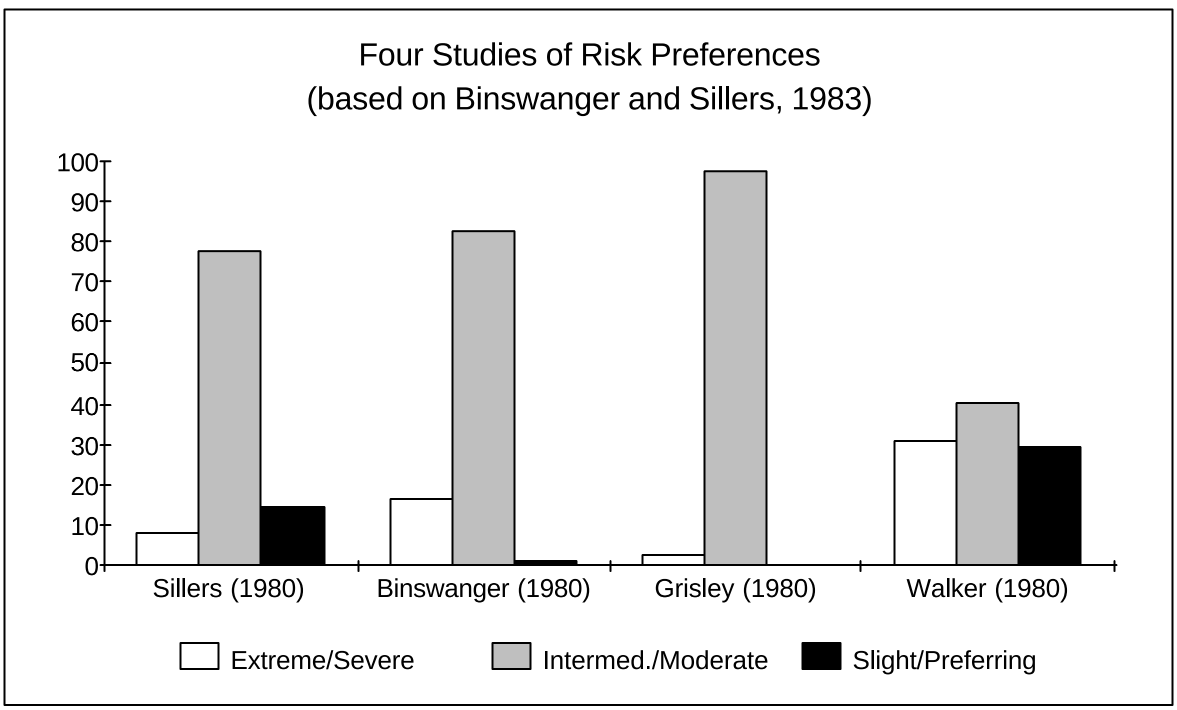

Figure 2. All four studies found a unimodal distribution with a peak in the intermediate/moderate range.

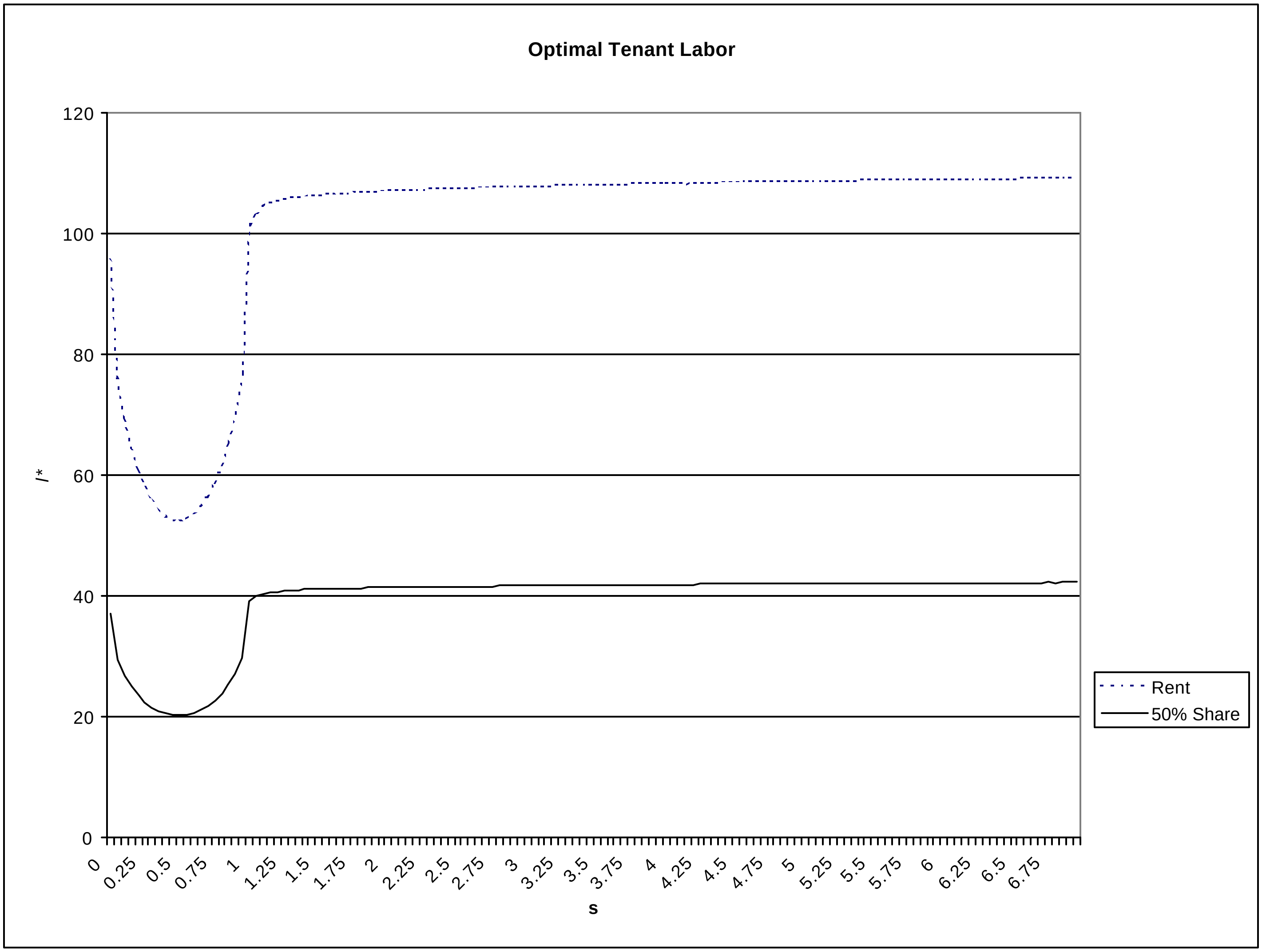

Figure 3: The tenant's optimal labor input (l^*) as a function of risk aversion (s).

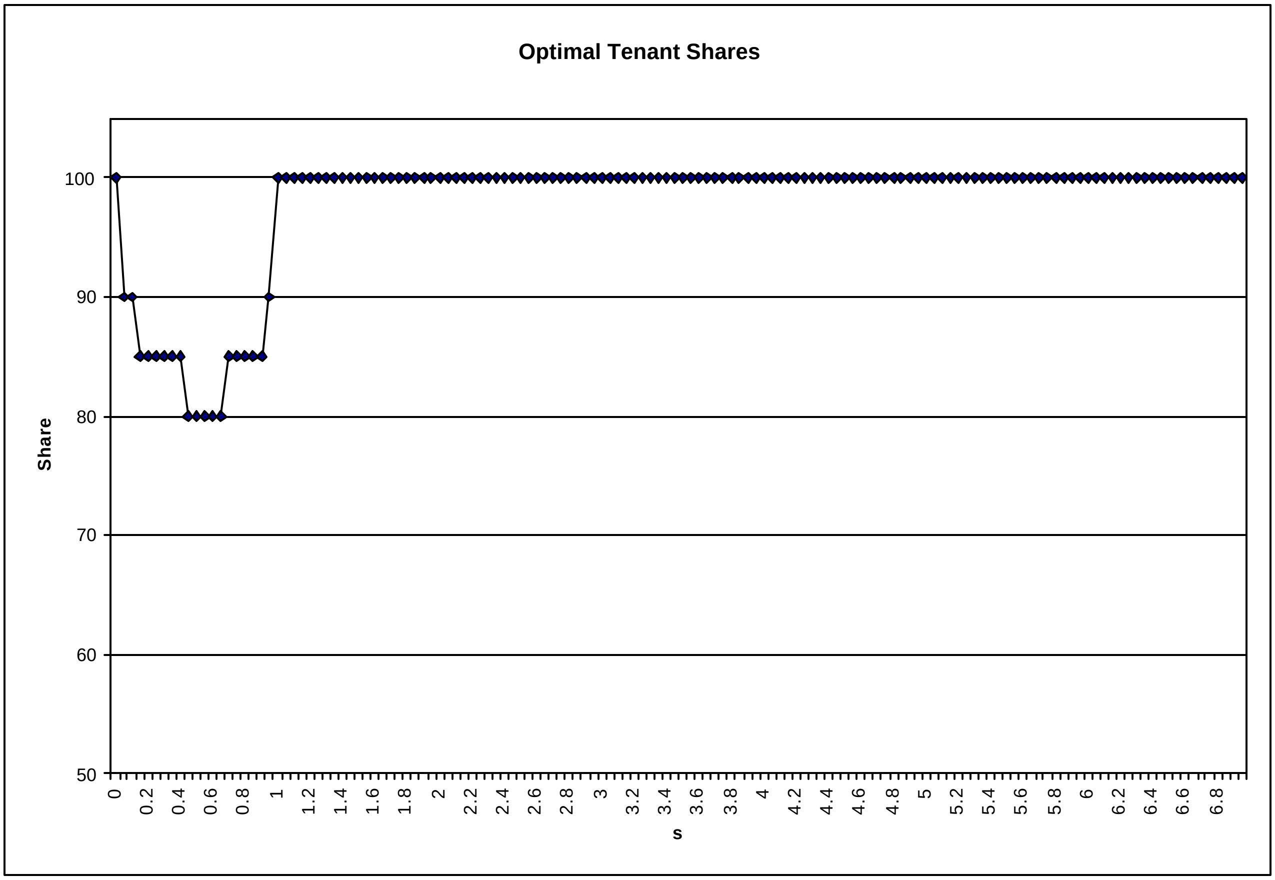

Figure 4: The optimal tenant share (α) as a function of risk aversion (s).

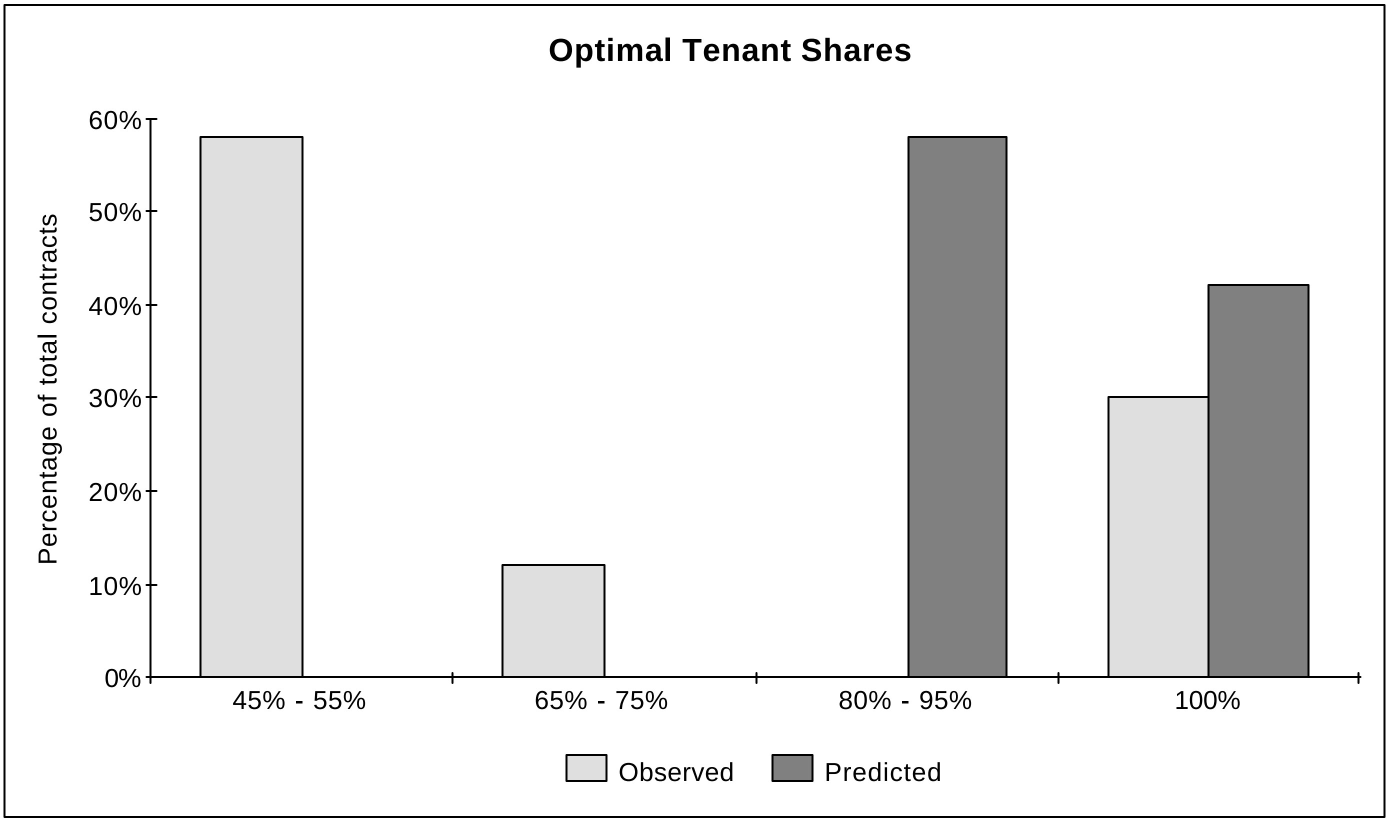

Figure 5: The model fails to predict the observed distribution of contracts.